Letter Health Consultation

Evaluation of Eastern Softshell Clam Contaminant Data at a Tulalip Tribal Consumption Rate

Warm Beach, Snohomish County, Washington

March 25, 2015

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

DOH 334-366 March 2015

Foreword

The Washington State Department of Health (DOH) prepared this health consultation in accordance with the Agency for Toxic Substances and Disease Registry (ATSDR) methodologies and guidelines. Health consultations are initiated in response to health concerns raised by community members or agencies about exposure to hazardous substances released into the environment. The health consultation summarizes our health findings and if needed, provides steps or actions to protect public health.

The findings in this report are relevant to conditions at the site during the time the report was written. It should not be relied upon if site conditions or land use changes in the future.

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March 25, 2015

Michael E. McHugh
Tulalip Tribes of Washington
Shellfish Program Manager
6404 Marine Drive
Tulalip, WA 98271

Re: Evaluation of Chemical Contaminant Data from Warm Beach Eastern Softshell Clams at Tulalip Tribes 95th Percentile Shellfish Consumption Rate
Warm Beach, Snohomish County, Washington

Dear Mr. McHugh:

At the request of the Tulalip Tribes of Washington, the Washington State Department of Health (DOH) has evaluated chemical contaminant data from Warm Beach eastern softshell clam (*Mya arenaria*) tissue at the Tulalip 95th percentile shellfish consumption rate.

This letter health consultation provides a hypothetical exposure scenario because it is limited to the evaluation of a single species of clam, and the clams that were evaluated were collected from an area that is prohibited or unclassified for commercial harvest; the prohibited area is also closed for recreational harvest. A more realistic exposure scenario would include multiple shellfish species that are sampled from actual harvest locations used by the Tulalip Tribes. In addition, the species of shellfish used in developing the Tulalip shellfish consumption rate include the following:

- Manila/littleneck clams, horse clam, butter clam, cockles, mussels, oysters, shrimp, crabs (Dungeness and Red Rock), moon snail, scallops, squid, sea urchin, sea cucumber

- Geoduck, limpets, lobster, razor clam, chiton, octopus, abalone, barnacles, crayfish, and other.(1)

This consult only addresses chemical contaminants; no microbial contaminants were evaluated.

Based on the evaluation of the Snohomish County Public Works clam contaminant data from Warm Beach, consuming these clams at the 95th percentile Tulalip shellfish consumption rate

may result in some non-cancer human health effects from cadmium and cancer risk from arsenic. The following is a summary of the findings and recommendations.

Background and Statement of Issues

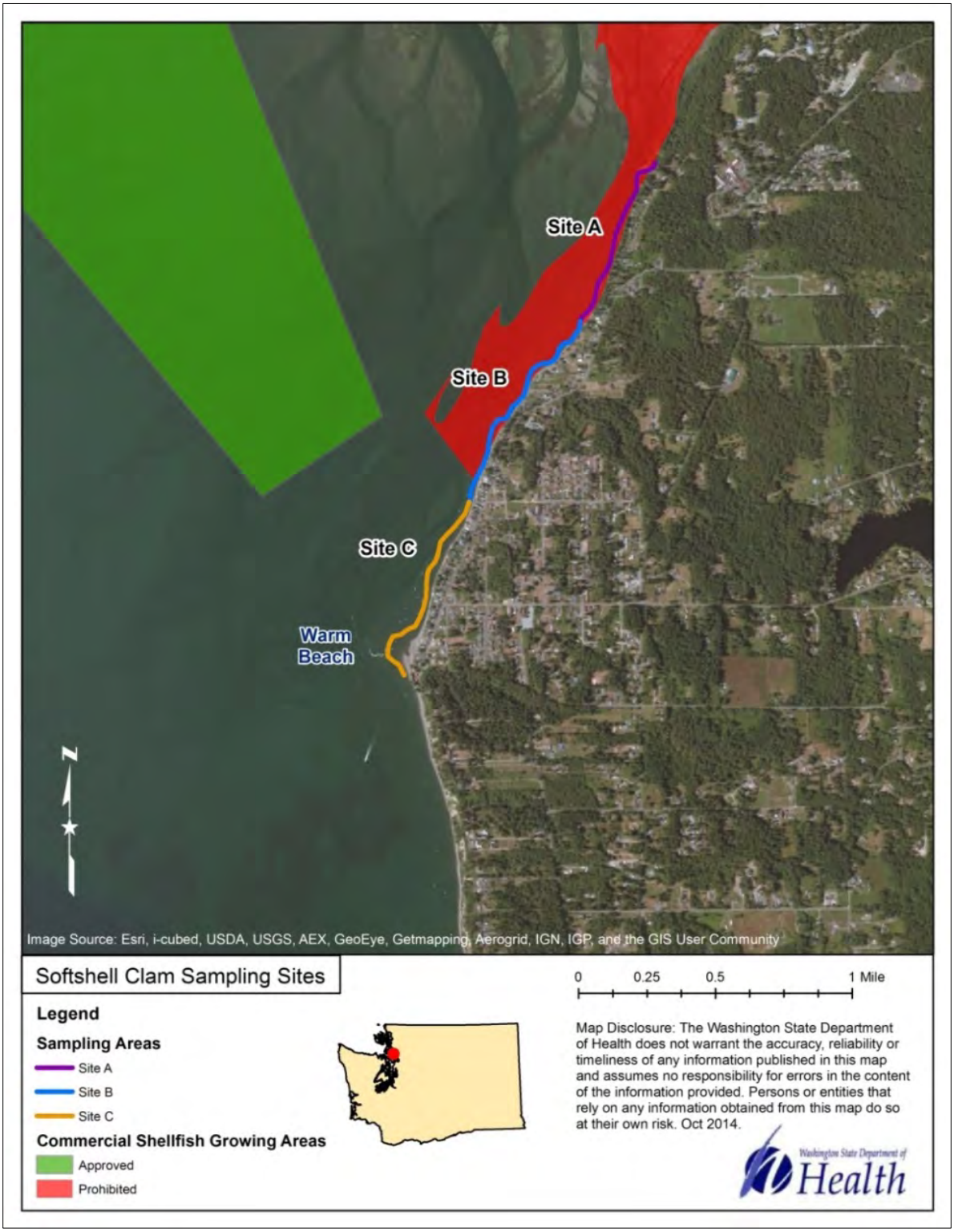
This letter health consultation was completed for the Tulalip Tribes as a follow-up to their inquiry about the December 2014 letter to Snohomish County Public Works.[2] Fish and shellfish consumption rates for tribes/subsistence consumers are, in general, significantly higher than consumption rates established for other populations. A shellfish consumption rate typically used in health risk assessment for recreational harvesters is 1.7 grams of shellfish per day, which is about 10% of the EPA-established general population fish and shellfish consumption rate.[3] In contrast, a high-end 95th percentile Tulalip Tribal member is reported to eat about 148 grams of shellfish each day.[1]

Previously, in response to a request from Snohomish County Public Works, DOH reviewed chemical contaminant data from clams to determine if there was a potential human health risk from consuming these clams as members of the Warm Beach community (i.e. private non-tribal tideland owners).This letter health consultation will evaluate the same clam dataset while using the Tulalip 95th percentile shellfish consumption rate for health risk assessment.

Warm Beach is located along the shores of Port Susan in Snohomish County. This beach supports private, non-tribal recreational shellfish harvesting; there are approximately 230 private tideland owners in the vicinity.[4]

Figure 1 outlines the areas where clams were sampled. The clams were collected on September 8, 2014 from Warm Beach tidelands by Snohomish County.

Figure 1: Softshell Clam Sampling Areas, Warm Beach, Snohomish County, Washington



The DOH Office of Shellfish and Water Protection is responsible for classifying commercial and recreational shellfish growing areas. Commercial shellfish growing areas are classified as Approved, Conditionally Approved, Restricted, or Prohibited. Recreational beaches are classified as Open, Conditionally Open, Emergency Closure, Closed, or Unclassified. Nearby, another area is classified as "Prohibited" due to proximity to a wastewater treatment plant outfall. The remaining area is "Unclassified" (no formal assessment has been conducted). Figure D1 (in Attachment D – Prohibited Shellfish Harvesting) shows a map of Port Susan area and its current classifications for shellfish growing and harvesting.

Discussion

Clam Study Dataset and Limitations

Five composite samples were collected along Warm Beach: two from Site A, two from Site B, and one from Site C (see Figure 1). Each composite was comprised of about 30 clams of legal harvest size. These clams were sent to AmTest Inc. where they were shucked and homogenized for chemical analysis. Each of these samples was analyzed for various metals, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). Concentrations were reported as dry weight clam tissue data.[5] DOH converted these concentrations to wet weight concentrations (see Attachment A – Calculations) to use in the health screening process in order to reflect typical seafood consistency consumed. Sample results only examine chemical contaminants and do not address potential health concerns regarding microbial contamination in shellfish.

Exposure Pathways

In order for any contaminant to be a health concern, the contaminant must be present at a high enough concentration to cause potential harm, and there must be a completed route of exposure to people.[6] An exposure pathway has five parts:

- Source of contamination (e.g. creosote pilings);
- Environmental Media and Transport Mechanism (e.g. biota);
- Point of Exposure (e.g. tidelands);
- Route of Exposure (eating, drinking, breathing, or touching); and
- Receptor Population (consumers).

When all five parts are present, it is considered a completed exposure pathway. When one or more parts are missing, a potential exposure pathway exists. The Tulalip Tribes are not harvesting eastern softshell clams from Warm Beach tidelands, so they are considered a potentially exposed population.

Health Screening Evaluation

Preliminary Screening

DOH generated screening values for each contaminant using the Environmental Protection Agency (EPA) guidance method for fish advisories.[7] These risk-based screening values are a basis for assessing whether chemical contaminant concentrations present in clam tissue are a concern to human health when consumed. For details on the screening process, see Attachment A – Calculations.

For preliminary screening, it was assumed that all shellfish consumed are clams with the highest levels of contaminants from Warm Beach. The highest level of each chemical was then compared to its screening value to see if it would pose a potential health problem. Both non-cancer and cancer health effects (when applicable to a chemical) were part of the screening process. If the highest concentration of a chemical exceeds its calculated screening value, DOH analyzes the chemical further and categorizes it as a "chemical of concern" (COC). For details, see Attachment B – Screening of Chemicals.

Exposure Assessment

There are many factors that determine whether an exposure will cause adverse health effects. Factors include the concentration of chemicals a person is exposed to, duration of exposure, how chemicals enter the person (through touching, eating, and/or breathing), other chemicals a person is exposed to, an individual's age, health and nutritional status. An exposure assessment uses environmental data to estimate doses of chemicals people are exposed to and predicts the risk of non-cancer and cancer health effects, when applicable, for each chemical. Health risk assessment summaries are provided below. For details see Attachment C – Non-Cancer Exposure Assessment and Cancer Risk.

Non-cancer Health Effects

Cadmium and copper were categorized as COCs; hazard quotients were calculated for each of chemicals to assess the risk of developing non-cancer health effects. No health effects are expected from copper; symptoms of overdose would include gastrointestinal upset and liver damage. However, cadmium was identified as a potential threat to human health. Chronically consuming cadmium will lead to build-up of cadmium in kidneys. Health effects that could potentially occur at a 95th percentile Tulalip shellfish consumption rate include potential kidney damage and proteinuria (excess excretion of protein in urine).

Cancer Risk

Cancer is a common illness that increases in susceptibility with age. About 1 in 3 people living in the U.S. will develop cancer at some point in their lives.[8] In addition to this general risk of cancer, there is some additional cancer risk from exposure to arsenic if Warm Beach eastern softshell clams were consumed at the 95th percentile Tulalip shellfish consumption rate. Approximately 7 additional cases of cancer is expected to develop for every 10,000 people

consuming Warm Beach eastern softshell clams at the 95th percentile Tulalip shellfish consumption rate. This additional risk is also referred to as a 7-in-10,000 "excess cancer risk."

Due to high analytical detection limits in the PCBs and PAHs data, there is too much uncertainty for DOH to assess risk (for details see Attachment B – Screening of Chemicals), and these chemicals were not included in the excess cancer risk calculated from exposure to arsenic.

Conclusions

DOH concludes that the concentrations of chemicals found in clams collected from the Warm Beach area and if consumed at the Tulalip 95th percentile shellfish consumption rate would potentially result in some non-cancer health effects with cadmium exposure and present some level of cancer risk (7-in-10,000 excess cancer risk) from arsenic. However, this is a hypothetical risk assuming that all the shellfish being consumed by the 95th percentile shellfish consumer in the Tulalip Tribes was comprised of only eastern softshell clams from Warm Beach tidelands.

Recommendations

DOH recommends that future sampling include species that are typically consumed and collected from actual harvest locations used by the Tulalip Tribes. Additionally, PCB congener analysis is recommended instead of PCB Aroclor analysis and lower detection targets should be set for PCB and PAH analysis for subsistence consumers in general.

DOH appreciates the opportunity to review and assist in the evaluation of the clam sampling data from Warm Beach for the Tulalip Tribes. A copy of this letter will be placed on the DOH Site Assessments webpage: http://www.doh.wa.gov/consults. If you have any questions regarding this letter please contact me at 360-236-3357 or by email at Amy.Leang@doh.wa.gov.

Sincerely,

Amy Leang
Health Assessor, Toxicologist
Site Assessments and Toxicology Section

cc: Joanne Snarski, Department of Health

Attachment A – Calculations

Calculations are based on Environmental Protection Agency (EPA) methodology[7]

Equations used in Health Risk Assessment

Non-cancer Health Effects	Cancer Health Effects
$SV = \frac{[(MRL\ or\ RfD) \times BW]}{CR}$ $Dose = (C \times CR)/BW$ $HQ = Dose/MRL$	$SV = \frac{\left[\left(\frac{RL}{CSF}\right) \times BW\right]}{CR}$ $Risk = Dose\ \times CSF$

SV = Screening value (mg/kg or ppm)
Dose (mg/kg/day)
Risk (unitless)
HQ = Hazard Quotient (unitless)
C = Concentration (mg/kg or ppm)
MRL = Minimal risk level (mg/kg/day)
RfD = Reference dose (mg/kg/day)
BW = Mean body weight (kg) = 81 kg, Average Tulalip Adult
RL = Risk level (life time cancer risk) = $1x10^{-5}$
CSF = Oral cancer slope factor $(mg/kg/day)^{-1}$, contaminant-specific
CR = consumption rate (kg/day) = 0.1479 kg/day, 95th Percentile Tulalip Shellfish CR[1]

Conversion from Dry Weight to Wet Weight Concentrations

Wet Weight = Dry Weight × [100 - % Water Content] /100
= Dry Weight × [% Total Solids*] /100

*Total Solids in each sample ranged from 10.3% - 14.0%.

Attachment B – Screening of Chemicals

Table B1. Non-Cancer Health Effects Screening of Metal Concentrations in Clams from Warm Beach at Tulalip 95th Percentile Shellfish Consumption Rate, Snohomish County, WA

Metal	EPA Cancer Class	Maximum Concentration (ppm)	MRL (mg/kg/day)	Screening Value (ppm)	Reference for Screening Values	Contaminant of Concern
Arsenic (inorganic)[a]	A	0.07	0.0003	0.16	MRL, Chronic-Oral	No
Cadmium	B1	0.39	0.0001	0.055	MRL, Chronic-Oral	**Yes**
Copper	D	18.7	0.01	5.5	MRL, Intermediate-Oral	**Yes**
Lead	B2	1.40	NA	NA	EPA Exposure Model	[see Table B2]
Mercury	C	0.10	0.0003	0.16	MRL, Chronic-Oral	No
Zinc	IN	13.1	0.3	164	MRL, Chronic-Oral	No

MRL: Minimal Risk Level from Agency for Toxic Substances & Disease Registry
ppm: parts per million
mg/kg/day: milligrams per kilogram per day
EPA (Environmental Protection Agency) Cancer Class -
A: Human Carcinogen
B1: Probable Human carcinogen based on limited evidence in humans and sufficient evidence in animals
B2: Probable human carcinogen based on sufficient evidence in animal
C: Possible human carcinogen
D: Not classifiable as to its carcinogenicity to humans
IN: Inadequate information to assess carcinogenic potential

[a] The arsenic concentration was given as total arsenic in the data set, although only inorganic arsenic is known to be harmful. The arsenic concentration was multiplied by 1% to account for this, as studies have shown that this is the estimated proportion of inorganic arsenic in shellfish.[(9)]

Table B2: Integrated Exposure Uptake Biokinetic (IEUBK) Model to Predict Lead Poisoning at Tulalip Child Consumption Rates, Assuming all Shellfish are Eastern Softshell Clams from Warm Beach, Snohomish County, WA

Maximum Lead Concentration (ppm)	Proportion of Meat Intake as Shellfish (%)	Children with Blood Lead Levels ≥ 5 µg/dL (%)	Public Health Concern
1.4	10%	1%	No

Results are based on the IEUBK Model Version 1.1 Build 11; input parameters from Environmental Protection Agency.
ppm: parts per million, µg/dL:micrograms per deciliter of blood; % : percent, ≥: greater than or equal to

The IEUBK model for lead exposure assumes that a child's total meat intake is 93.5 g/day. EPA's target cleanup goal is no more than 5% of the community with BLLs above 10 µg/dL.

Parameters used in model:
Consumption rates: Tulalip Tribes child – 90th percentile shellfish (.597 g/kg/day)[(1)]
Average child body weight: 16 kg
IEBUK Model assumes that 10.2% of all meat consumed by Tulalip Tribes child is shellfish.

There would be no health concerns for lead poisoning at Tulalip consumption rates assuming all shellfish consumed were eastern softshell clams sampled from Warm Beach.

Table B3. Non-Cancer Health Effects Screening of Polycyclic Aromatic Hydrocarbons (PAHs) Concentrations in Clams from Warm Beach at Tulalip 95th Percentile Shellfish Consumption Rate, Snohomish County, WA

PAHs	EPA Cancer Class	Concentration (ppb)	MRL or Reference Dose (mg/kg/day)	Screening Value (ppb)	Reference for Screening Values	Contaminant of Concern
2-Methylnaphthalene		<3.33	0.6	328600	Naphthalene, MRL Int-Oral	No
acenapthylene		<3.33	0.03	16430	Pyrene RfD surrogate	No
acenaphthene		<3.33	0.6	328600	MRL, Intermediate-Oral	No
fluorene	D	<3.33	0.04	21907	RfD, Chronic Oral	No
phenanthrene	D	<3.33	0.3	164300	Anthracene RfD surrogate	No
anthracene	D	<3.33	0.3	164300	RfD, Chronic Oral	No
fluoranthene	D	<3.33	0.04	21907	RfD, Chronic Oral	No
pyrene	D	<3.33	0.03	16430	RfD, Chronic Oral	No
benz(a)anthracene	B2	<3.33	0.03	16430	Pyrene RfD surrogate	No
chrysene	B2	<3.33	0.03	16430	Pyrene RfD surrogate	No
benzo(b)fluoranthene	B2	<3.33	0.04	21907	Fluoranthene RfD surrogate	No
benzo(j,k)fluoranthene	B2	<3.33	0.04	21907	Fluoranthene RfD surrogate	No
benzo(a)pyrene	B2	<3.33	0.03	16430	Pyrene RfD surrogate	No
indeno(1,2,3-c,d)pyrene	B2	<3.33	0.04	21907	Fluoranthene RfD surrogate	No
dibenz(a,h)anthracene	B2	<3.33	0.03	16430	Pyrene RfD surrogate	No
benzo(g,h,i)perylene	D	<3.33	0.03	16430	Pyrene RfD surrogate	No

MRL: Minimal Risk Level from Agency for Toxic Substances & Disease Registry
RfD: Reference Dose from EPA
ppb: parts per billion
mg/kg/day: milligrams per kilogram per day
EPA (Environmental Protection Agency) Cancer Class -
B2: Probable human carcinogen based on sufficient evidence in animals
D: Not classifiable as to its carcinogenicity to humans

Table B4. Non-Cancer Health Effects Screening of Polychlorinated Biphenyls (PCBs) Concentrations in Clams from Warm Beach at Tulalip 95th Percentile Shellfish Consumption Rate, Snohomish County, WA

PCBs	EPA Cancer Class	PQL (ppb)	MRL or RfD (mg/kg/day)	Screening Value (ppb)	Reference for Screening Values	Contaminant of Concern
PCBs (Aroclor 1254)	B2	<17	0.00002	11	MRL, Chronic-Oral	Indeterminate
PCBs (Aroclor 1016)	B2	<17	0.00007	38	Oral RfD	No

PQL: No PCBs were detected; reported concentrations are the highest Practical Quantitation Limits (PQLs). No MRLs or RfDs have been established for other PCB aroclors.
EPA: Environmental Protection Agency
MRL: Minimal Risk Level from Agency for Toxic Substances & Disease Registry
RfD: Reference Dose from EPA
B2: Probable human carcinogen based on sufficient evidence in animals
ppb: parts per billion ; mg/kg/day: milligrams per kilogram per day

Note: For PCBs (Aroclor 1254), calculated screening values were below the highest Practical Quantitation Limit (PQL). A contaminant of concern (COC) is further evaluated when it is suspected of being present (i.e. when there are 1 or more PCB Aroclors detected). However, in this dataset, PCBs are not suspected of being contaminants; all Aroclors analyzed were non-detects. The reason why PCBs were labeled "indeterminate" is because the PQL exceeds the screening value. A lower limit of detection or PCB congener analysis (as opposed to Aroclor analysis) is suggested for future studies.

Table B4 ends the preliminary non-cancer health effects screening. Two COCs were identified: cadmium and copper. These contaminants will be further addressed in an exposure assessment (Attachment C).

For screening cancer health effects, analytes with probable or likely cancer class categorization were analyzed further. Cadmium is known to be carcinogenic, but only when inhaled. Therefore, arsenic was the only metal to be screened for cancer (Table B5), and will be further evaluated in cancer risk assessment (Attachment C).

Table B5: Cancer Health Effects Screening of Arsenic in Clams from Warm Beach at Tulalip 95th Percentile Shellfish Consumption Rate, Snohomish County, WA

Metal	Concentration (ppm)	Screening Value (ppm)	EPA Cancer Class	Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Carcinogenic Contaminant of Concern
Arsenic (Inorganic)	0.07	0.00096	A	5.7	**Yes**

EPA (Environmental Protection Agency) Cancer Class A: Human Carcinogen
ppm: parts per million; $mg/kg/day^{-1}$: inverse of milligrams per kilograms body weight per day

Table B6: Indeterminate Cancer Screening of Clams for Chemicals and Comparison of Practical Quantitation Limits with Tulalip 95th Percentile Shellfish Screening Value, Warm Beach, Snohomish County, WA

Chemical	Practical Quantitation Limit (ppb)	Screening Value (ppb)	Carcinogenic Contaminant of Concern
PCBs	<17	2.7	Indeterminate
Total cPAHs TEQ	<8	0.75	

ppb: parts per billion

Note: Cancer screening was indeterminate for PCBs and cPAHs. Screening levels based on the Tulalip 95th percentile shellfish consumption rate were lower than the Practical Quantitation Limits (PQLs) of PCBs and cPAHs (Table B6). A lower limit of detection or PCB congener analysis (as opposed to Aroclor analysis) is suggested for future studies.

Attachment C – Non-Cancer Exposure Assessment and Cancer Risk

Table C1: Non-Cancer Hazard Quotients of Chemical Contaminants of Concern Identified from Warm Beach Eastern Softshell Clams at the 95th Percentile Tulalip Consumption Rate, Snohomish County, WA

Contaminant	Maximum Concentration (ppm)	Estimated Dose (mg/kg/day)	MRL (mg/kg/day)	Hazard Quotient (Dose/MRL)	Dose Comparison (mg/kg/day)	Reference Value[b]
Cadmium	0.39	7.1E-04	0.0001	7.1	3.3E-04	$UCDL_{10}$
Copper	18.7	3.4E-02	0.01	3.4	4.2E-02	NOAEL

MRL: Minimal Risk Level from Agency for Toxic Substances & Disease Registry
ppm: parts per million ; mg/kg/day: milligrams per kilogram per day
$UCDL_{10}$: lower 95% estimate of urinary cadmium dose corresponding to a 10% excess risk of proteinuria
NOAEL: No-observed-adverse-effect level

There are potential health effects expected from cadmium if the 95th percentile Tulalip shellfish consumer's entire shellfish diet was comprised of eastern softshell clams from Warm Beach. See below for additional notes on hypothetical exposures to both contaminants of concern.

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[b] The Cadmium MRL was based on a meta-analysis of available environmental exposure studies.(10) Chronically consuming cadmium will lead to build-up of cadmium in kidneys, which can cause some kidney damage; in particular, exposure studies examined the health endpoint of low molecular weight proteinuria. The lower [95%] estimate of urinary cadmium dose (3.3E-04 mg/kg/day) corresponding to a 10% excess risk of proteinuria, referred to as the $UCDL_{10}$, was used by ATSDR to derive the MRL.(10) Since the estimated exposure dose exceeds the $UCDL_{10}$, kidney problems from cadmium may be an issue if the 95th percentile Tulalip shellfish consumer's entire shellfish diet was comprised of eastern softshell clams from Warm Beach.

The Copper MRL was based on a 2003 study by Araya et al.(11) NOAEL values (taking into consideration normal copper dietary intake) were identified from this study and used to derive the MRL. Symptoms of copper overdose include gastrointestinal upset and liver damage.(12) The estimated dose of copper does not excess the NOAEL. Therefore, no health effects would be expected even if the 95th percentile Tulalip shellfish consumer's entire shellfish diet was comprised of eastern softshell clams from Warm Beach.

Table C2: Cancer Risk of Chemical Contaminants of Concern Identified from Warm Beach Eastern Softshell Clams at the 95th Percentile Tulalip Consumption Rate, Snohomish County, WA

Chemical	EPA Cancer Class	Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Concentration (ppm)	Dose (mg/kg/day)	Cancer Risk
Arsenic (Inorganic)	A	5.7	0.07	0.00013	**7.E-04**

ppm: parts per million; $mg/kg/day^{-1}$: milligrams per kilograms body weight-day

Cancer risk for arsenic is expected to be "low to moderate", assuming the 95th percentile Tulalip shellfish consumer's entire shellfish diet was comprised of eastern softshell clams from Warm Beach. Excess cancer risk is approximately 7 additional cases per 10,000 people, with particular increased risk for skin, liver, bladder, and/or lung cancer from chronic oral arsenic exposure.[13]

Attachment D – Prohibited Shellfish Harvesting

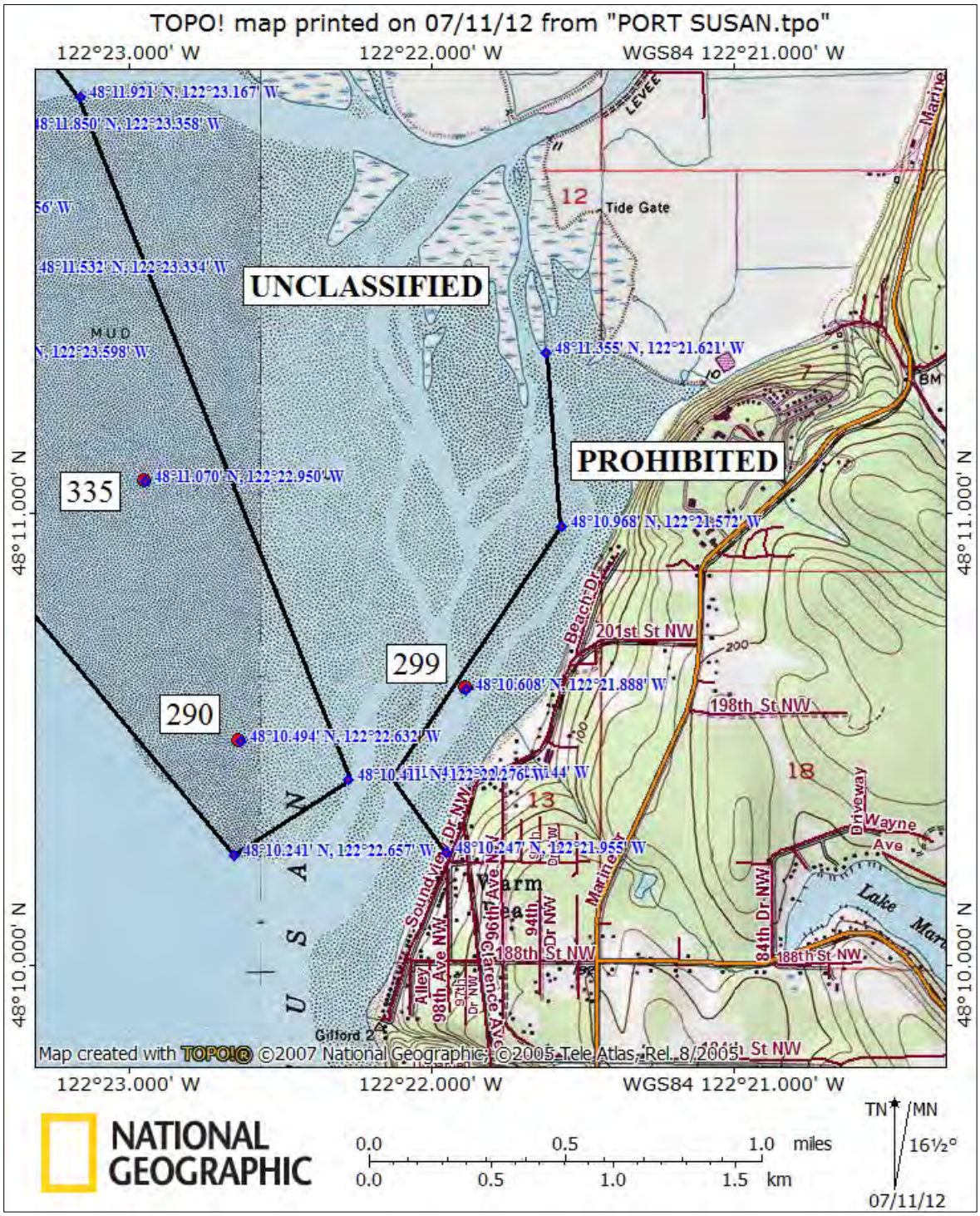

Figure D1: Topographic Map of Commercial Shellfish Growing Areas in Port Susan (Washington State Department of Health Office of Shellfish and Water Protection, URL: http://www.doh.wa.gov/Portals/1/Documents/4400/portsusan.pdf)

References

(1) Toy K, Polissar N, Liao S, Mittelstaedt G. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region. 1996.

(2) Washington State Department of Health. Letter Health Consultation, Evaluation of Chemical Contaminant Data from Eastern Softshell Clams. 2014. Olympia, WA.

(3) U.S.Environmental Protection Agency. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. 3[1]. 2000.

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(5) AmTest Laboratories. Analytical Data AMTEST ID 14-A014241 - 14-A014245. Prepared by Aaron Young. 2014. Kirkland, WA.

(6) Agency for Toxic Substances and Disease Registry (ATSDR). Public Health Assessment Guidance Manual (Update). 2005.

(7) U.S.Environmental Protection Agency. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. 3[1]. 2000.

(8) American Cancer Society. Cancer Facts & Figures 2014. 2014.

(9) Washington State Department of Ecology. Inorganic arsenic levels in Puget Sound fish and shellfish from 303(d) listed water bodies and other area, Prepared by Art Johnson and Morgan Roose. 2002. Olympia, WA.

(10) Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Cadmium. 2011. Atlanta, Georgia, U.S. Department of Health and Human Services, Public Health Service. 6-9-2014.

(11) Araya M, Olivares M, Pizarro F, et al. Gastrointestinal symptoms and blood indicators of copper load in apparently healthy adults undergoing controlled copper exposure. Am J Clin Nutr 2003; 77(3):646-650.

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(13) Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Arsenic. 2011. Atlanta, Georgia, U.S. Department of Health and Human Services, Public Health Service. 6-5-2014.